Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Delaware Division of Fish and Wildlife 30-foot otter trawl survey

Camilla T. McCandless and Michael Greco

SEDAR39-DW-15

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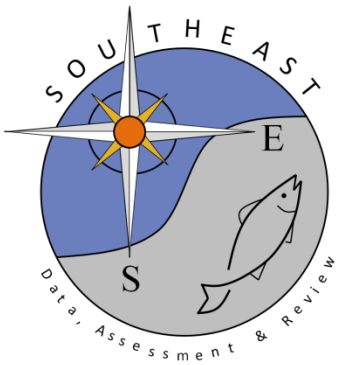

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SEDAR 39 DATA WORKSHOP DOCUMENT

Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Delaware Division of Fish and Wildlife 30-foot otter trawl survey

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Summary

This document details the smooth dogfish, *Mustelus canis*, catch from the Delaware Bay 30-foot otter trawl survey from 1966-1971, 1979-1984, and from 1990-2013. Catch per unit effort (CPUE) in number of sharks per nautical mile towed were examined by year. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. The standardized relative abundance for smooth dogfish shows an initial decrease in relative abundance during the 1970s with continued low levels in the early 1980s, followed by an overall increasing trend from the 1990s through 2013. During the end of the time series a large drop in abundance is seen in 2004 and 2005. These years were particularly busy with strong summer storms in the area bringing high rainfall and rough seas to Delaware Bay.

Introduction

The Delaware Division of Fish and Wildlife uses the Delaware Bay 30-foot trawl survey to monitor sub-adult and adult fish abundance for the development of interstate fishery management plans and stock assessments. Data from this survey is also used in establishing time of year restrictions for such things as beach replenishment and dredging. In addition, this survey serves as a platform for collecting specimens for researchers studying genetics, tissue contaminants, age and growth, and food habits. In this document, the Delaware Bay trawl time series is modeled to create a standardized index of abundance for smooth dogfish, *Mustelus canis*.

Methods

Sampling gear and survey design

In starting the current survey (1990-present), efforts were made to replicate sampling and gear protocol of the previous (1966-1971 and 1979-1984) 30-foot trawl surveys conducted in Delaware Bay by Abbe (1967), Daiber and Wockley (1968), Daiber and Smith (1972), and Smith (1987). Retired University of Delaware research vessel captain Tom White served as consultant to the project, making the necessary gear adjustments to ensure consistency. In addition, several members of the biological staff that served onboard the previous survey (1979 – 1984) were on hand during the testing phase to further ensure catches were sampled correctly and the gear was fished properly. Data forms from the previous surveys were used to ensure consistency in data recording.

Early sampling was conducted with the University of Delaware's *R/V Wolverine*, a 47-foot (14.3- m) A-framed stern trawler. Sampling from March 1990 through July 2002 was conducted using the 65-foot (20-m) *R/V Ringgold Brothers*. The *R/V Ringgold Brothers* was a wooden displacement-hulled skipjack converted to power and was equipped with an eastern-rigged trawling system that deployed and retrieved the trawling gear from the starboard side. The State of Delaware purchased a custom-built stern-rigged research vessel which began service as the survey's research platform in August of 2002. The 62-foot (19-m) deep-*V* semi-displacement hulled *R/V First State* is equipped with an *A*-frame stern trawling rig. Tow durations in some of the previous surveys were 30 minutes; whereas, tow durations in the present survey were 20 minutes. Tows less than 20-minutes were rarely made (due to gear conflicts, etc.); however, in such cases, a 10- minute minimum tow time was required for the tow to be considered valid. Sampling was generally conducted from March through December in the present survey; although, previous sampling efforts were occasionally conducted year-round or were greatly abbreviated.

The net used in the survey consisted of 3-inch (7.6-cm) stretch mesh in the wings and body, and 2-inch (5.1-cm) stretch mesh in the cod end. The trawl had a 30-foot 6-inch (9.3-m) x 1/2-inch (1.2-cm) headrope and a 39-foot 6-inch (12.0-m) x 1/2-inch footrope with 40-foot (12.2-m) leglines. The 54-inch x 28-inch (1.37-m x

0.71-m) doors were constructed of ¾-inch (1.9-cm) virgin pine lumber, bolted to a 2 inch x 4 inch (5.1cm x 10.2cm) strong back. The doors had a 2-inch x ¾-inch (5.1-cm x 1.9-cm) milled steel bottom shoe runner and ¼-inch (0.64-cm) galvanized chain bridles attached to ½-inch (1.3-cm) galvanized swivels at the head.
The lack of towable bottom required a fixed sampling scheme. Station locations from the previous surveys were used. There was some randomization in the selection of tow starting sites within each quadrant due to weather, currents and inaccuracy inherent with electronic positioning equipment. Station 51 was permanently relocated in 1998 to approximately 0.5 nautical miles south of the original station location due to repeated gear fouling on a fixed obstruction.

A global positioning system (GPS) was used to determine exact vessel position at the start and conclusion of each tow. Odometer readings from the GPS unit were used to determine distance towed (nautical miles). Mean water depth was determined from fathometer readings taken at five minute intervals including the start and finish points of each tow. A line-out to depth ratio of 6:1 was maintained. Upon completion of each tow, the sample was emptied on the deck and sorted by species. Aggregate weights were taken for each species. Species represented by less than 50 individuals were measured for fork length to the nearest half-centimeter. Species with more than fifty individuals were randomly sub-sampled (50 measurements) for length with the remainder being enumerated.

Data Analysis

Catch per unit effort (CPUE) in number of sharks per nautical mile towed were used to examine the relative abundance of smooth dogfish caught during the Delaware Bay trawl survey. The CPUE was standardized using the Lo et al. (2002) method which models the proportion of positive tows separately from the positive catch. Factors considered as potential influences on the CPUE for these analyses were: year (1966 – 1971, 1979 – 1984, and from 1990 – 2013), month (April - November), and station (11, 21, 31, 41, 51, 52, 62, 71, 72). The proportion of tows with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE tows were modeled assuming a lognormal distribution.

Models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model providing the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. The factor “year” was kept in all final models to allow for calculation of indices. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were then run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS MIXED procedure

(Wolfinger, SAS Institute, Inc). The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and lognormal components.

Results

A total of 30,901 smooth dogfish were caught during 2,081 tows. Smooth dogfish ranged in length from 16 to 100 cm FL and size remained consistent across time (Figure 2). The proportion of tows with positive catch (at least one smooth dogfish was caught) was 51%. The stepwise construction of each model and the resulting statistics are detailed in Table 1. Model diagnostic plots reveal that the model fit is acceptable (Figures 3a and 3b). There is an outlier in the residual plots for the proportion positive vs. year, month, and station, which comes from the only tow in October to catch a smooth dogfish at station 11 (the northernmost station). The resulting indices of abundance based on the year effect least square means, associated statistics, and nominal indices are reported in Table 2 and are plotted by year in Figure 4. The standardized relative abundance for smooth dogfish shows an initial decrease in relative abundance during the 1970s with continued low levels in the early 1980s, followed by an overall increasing trend from the 1990s through 2013 (Figure 4). During the end of the time series a large drop in abundance is seen in 2004 and 2005. These years were particularly busy with strong summer storms in the area bringing high rainfall and rough seas to Delaware Bay.

References

Abbe, G.R. 1967. An evaluation of the distribution of fish populations of the - Delaware River estuary. M.S. Thesis. (unpubl.) University of Delaware, Newark.

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

Daiber, F.C. and R.C. Wockley. 1968. An analysis of the fish populations in the Delaware Bay area. 1967-1968 Annual Dingle-Johnson Report to the Delaware Board of Game and Fish Commissioners. Project F-13-R-10, Job No. 3 and 5. Delaware Division of Fish and Wildlife, Dover.

Daiber, F.C. and R.W. Smith. 1972. An analysis of the fish populations in the Delaware Bay area. 1971-1972 Annual Dingle-Johnson Report F-13-R-14, Job I- 1. Delaware Division of Fish and Wildlife, Dover.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (*Thunnus albacares*) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Smith, R.W. 1987. Marine fish populations in Delaware Bay. 1982-87 Federal
Aid in Fisheries Restoration Project F-34-R , Final Report. Delaware Division of Fish and Wildlife, Dover.

Table 1. Results of the stepwise procedure for development of the DE trawl survey catch rate model for smooth dogfish. DF is the degrees of freedom. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	2019	2799.9799	1.3868		
STATION	2011	2110.7720	1.0496	24.3150	24.3150
MONTH	2012	2324.8337	1.1555	16.6787	
YEAR	1983	2666.6378	1.3447	3.0358	
STATION + MONTH	2004	1453.8984	0.7255	47.6853	23.3703
STATION + YEAR	1975	1950.7973	0.9877	28.7785	4.4635
STATION + MONTH + YEAR	1968	1211.6827	0.6157	55.6028	7.9175

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
STATION + MONTH + YEAR	12593	12598	12590

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	STATION	MONTH	YEAR
DF	8	7	36
CHI SQUARE	342.91	292.23	157.56

POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION

FACTOR	DF	DEVIANCE	DEVIANCE/DF	%DIFF	DELTA%
NULL	1022	2084.7099	2.0398		
STATION	1014	1772.3885	1.7479	14.3102	14.3102
MONTH	1015	1875.9338	1.8482	9.3931	
YEAR	986	1887.2420	1.9140	6.1673	
STATION + MONTH	1007	1543.9671	1.5332	24.8358	10.5255
STATION + YEAR	978	1579.0570	1.6146	20.8452	6.5350
STATION + MONTH + YEAR	971	1322.7735	1.3623	33.2140	8.3783

FINAL MODEL	AIC	BIC	(-2) Res Log Likelihood
STATION + MONTH + YEAR	3235.9	3249.8	3233.9

Type 3 Test of Fixed Effects

Significance (Pr>Chi) of Type 3 test of fixed effects for each factor	STATION	MONTH	YEAR
DF	8	7	36
CHI SQUARE	252.81	188.13	162.37

Table 2. DE trawl survey smooth dogfish analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as catch per nautical mile towed (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n sets	catch	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
1966	35	459	23	17	0.7391	16.7840	18.1564	8.9237	36.9412	0.3667
1967	31	443	23	16	0.6957	17.3305	16.2623	6.2621	42.2321	0.5057
1968	11	239	8	6	0.7500	27.1648	17.8712	3.8768	82.3810	0.8904
1969	21	201	14	10	0.7143	13.2428	7.8223	2.1102	28.9963	0.7321
1970	15	410	13	10	0.7692	25.9208	15.8232	5.1701	48.4268	0.6060
1971	19	422	16	12	0.7500	13.4416	8.7054	2.6037	29.1066	0.6629
1972	.	.	.	.	.	.	.	.	.	.
1973	.	.	.	.	.	.	.	.	.	.
1974	17	321	10	8	0.8000	21.3904	3.4362	0.6390	18.4786	1.0143
1975	.	.	.	.	.	.	.	.	.	.
1976	.	.	.	.	.	.	.	.	.	.
1977	.	.	.	.	.	.	.	.	.	.
1978	.	.	.	.	.	.	.	.	.	.
1979	62	230	62	16	0.2581	3.7108	0.8630	0.2799	2.6607	0.6106
1980	63	423	61	17	0.2787	6.4542	1.6046	0.5359	4.8049	0.5923
1981	67	645	63	28	0.4444	9.5926	5.7327	2.4342	13.5009	0.4487
1982	38	150	33	16	0.4848	5.4153	12.4446	5.1760	29.9204	0.4606
1983	35	91	31	7	0.2258	2.4860	1.4162	0.3214	6.2395	0.8561
1984	42	71	38	14	0.3684	2.0675	3.6739	1.2572	10.7363	0.5771
1985	.	.	.	.	.	.	.	.	.	.
1986	.	.	.	.	.	.	.	.	.	.
1987	.	.	.	.	.	.	.	.	.	.
1988	.	.	.	.	.	.	.	.	.	.
1989	.	.	.	.	.	.	.	.	.	.
1990	50	856	50	22	0.4400	18.5424	8.1992	3.1748	21.1748	0.5024
1991	63	716	63	28	0.4444	10.8893	5.8134	2.5281	13.3682	0.4351
1992	72	688	72	27	0.3750	8.8297	4.6194	1.9319	11.0453	0.4574
1993	71	1181	71	35	0.4930	15.1197	12.3726	6.3283	24.1902	0.3449
1994	54	887	54	15	0.2778	15.3690	5.0407	1.6637	15.2721	0.5997
1995	70	611	70	29	0.4143	7.6038	4.2235	1.8477	9.6540	0.4317
1996	67	1087	67	32	0.4776	14.4333	11.2386	5.4886	23.0125	0.3702
1997	71	1177	71	37	0.5211	15.3430	21.7285	11.9697	39.4437	0.3049
1998	62	1234	62	29	0.4677	16.9315	16.8656	7.9424	35.8140	0.3903
1999	69	903	69	35	0.5072	12.4631	21.1044	11.4401	38.9328	0.3135
2000	72	2518	72	42	0.5833	33.7167	36.0098	21.9592	59.0505	0.2511
2001	72	1716	72	41	0.5694	23.1679	31.0445	18.5172	52.0468	0.2627
2002	60	868	60	37	0.6167	13.6410	14.5337	8.6019	24.5558	0.2668
2003	54	2054	54	31	0.5741	40.2734	26.7053	14.5210	49.1135	0.3118
2004	72	422	72	31	0.4306	5.9074	4.2159	1.9387	9.1679	0.4035
2005	71	376	71	28	0.3944	5.2715	2.5878	1.1060	6.0550	0.4450
2006	72	2539	72	46	0.6389	34.2482	41.0351	26.9136	62.5662	0.2133
2007	72	1745	72	47	0.6528	23.3678	38.5583	25.5150	58.2694	0.2087
2008	72	743	72	36	0.5000	10.5156	9.5693	5.0293	18.2076	0.3301
2009	71	738	71	39	0.5493	10.2911	11.6523	6.6685	20.3610	0.2846
2010	72	866	72	50	0.6944	11.8497	19.4536	13.3870	28.2693	0.1885
2011	72	975	72	41	0.5694	15.6967	19.0886	11.3759	32.0303	0.2632
2012	72	1162	72	48	0.6667	15.8505	19.3537	13.0355	28.7341	0.1995
2013	72	734	72	40	0.5556	10.1297	14.4152	8.3772	24.8051	0.2765

Figure 1. Stations sampled with the 30-foot otter trawl in Delaware Bay. Numbers indicate assigned station numbers.

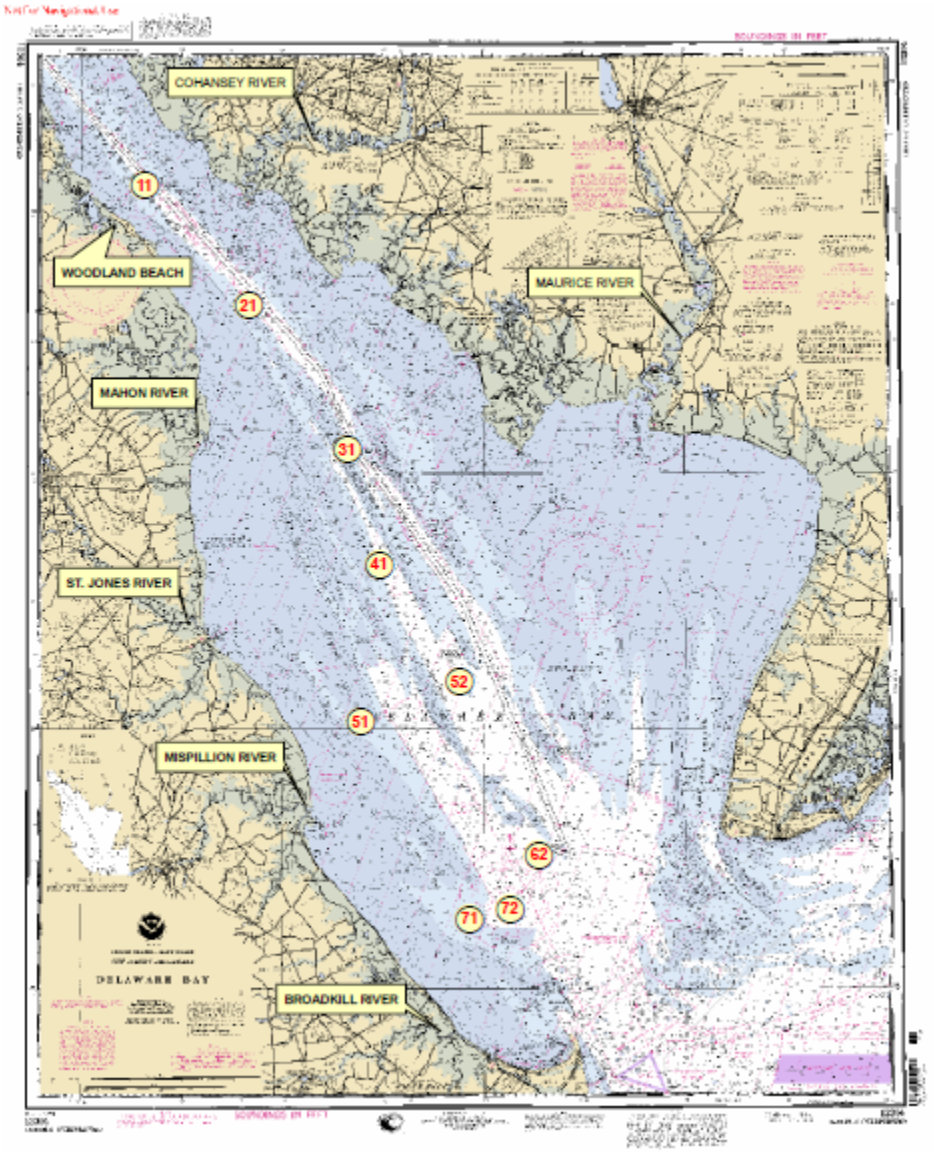


Figure 2. Fork lengths (cm) of smooth dogfish caught during the Delaware Bay trawl survey.

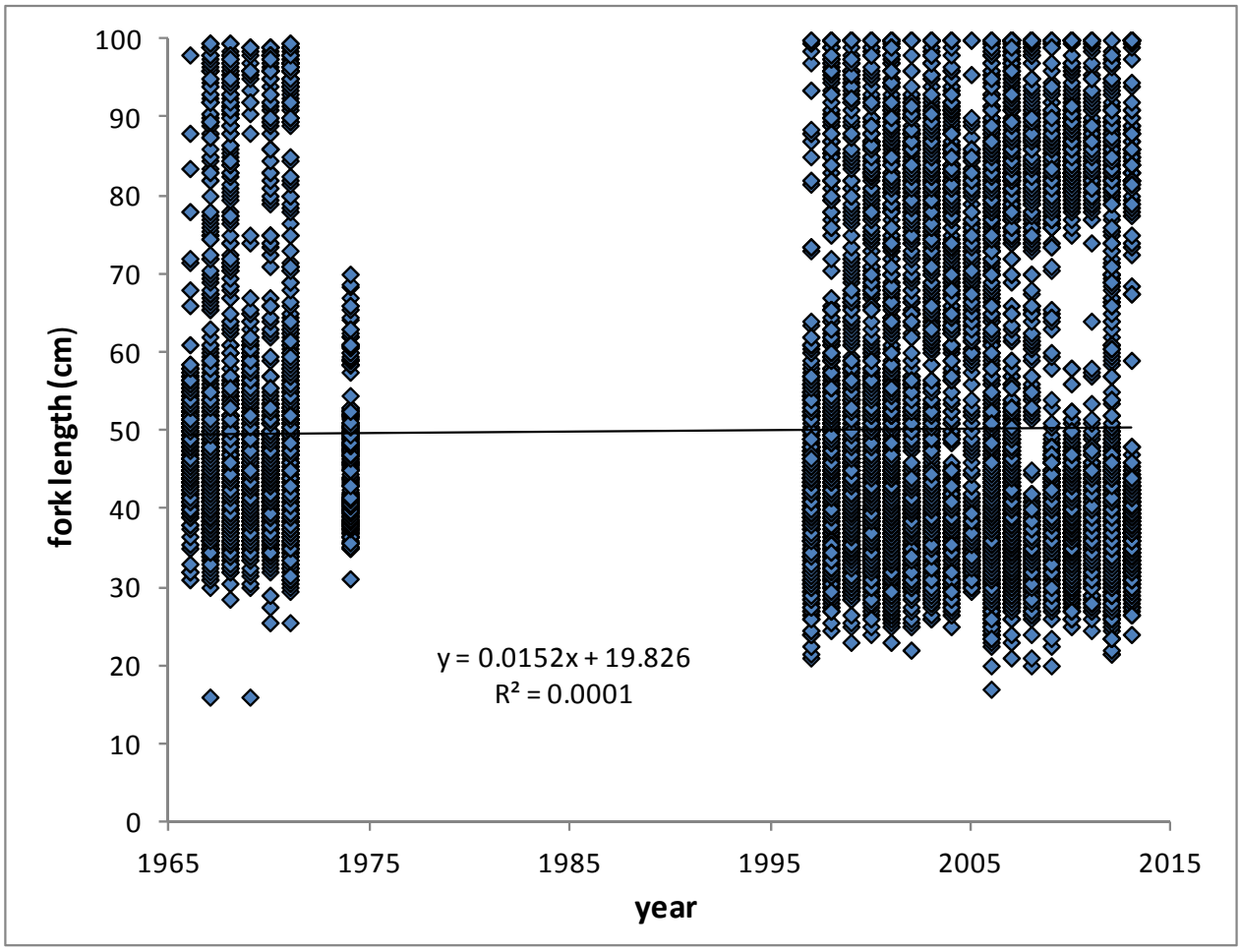
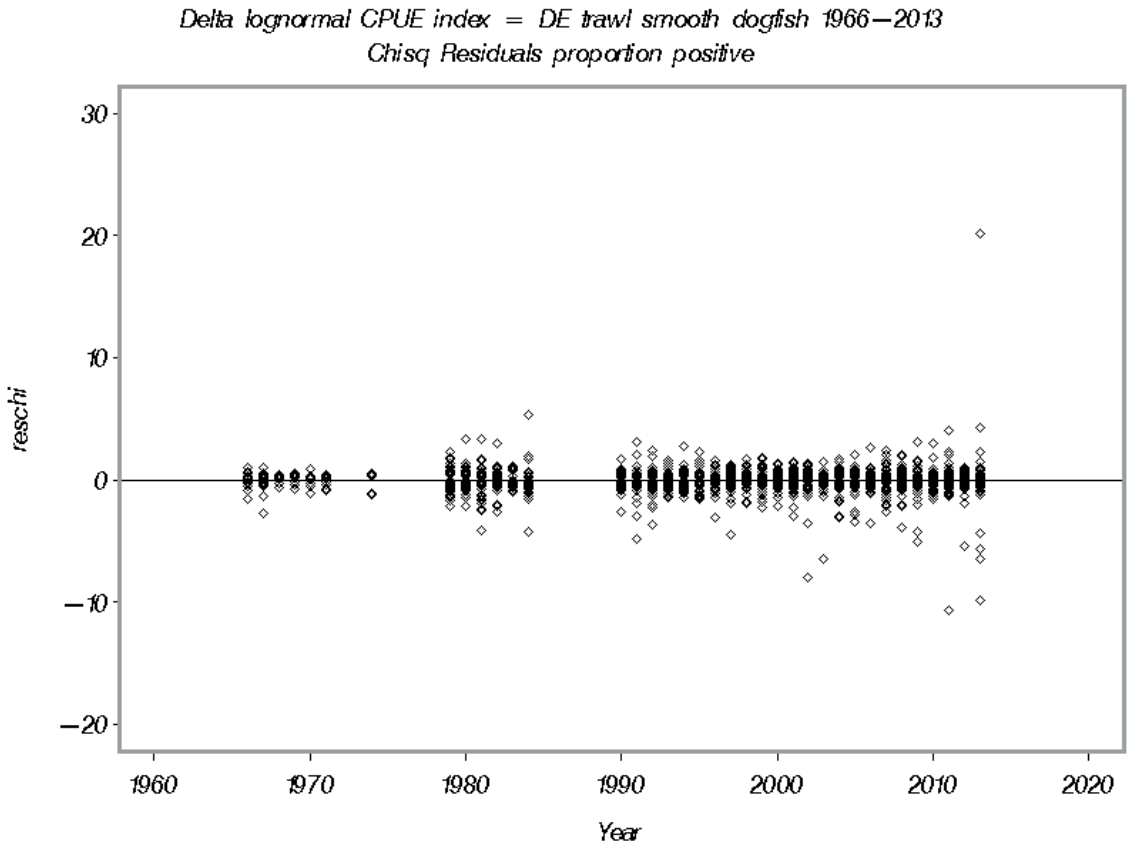


Figure 3a. Delaware Bay trawl survey smooth dogfish model diagnostic plots for the binomial component.


Delta lognormal CPUE index = DE trawl smooth dogfish 1966–2013
Chisq Residuals proportion positive
reschi
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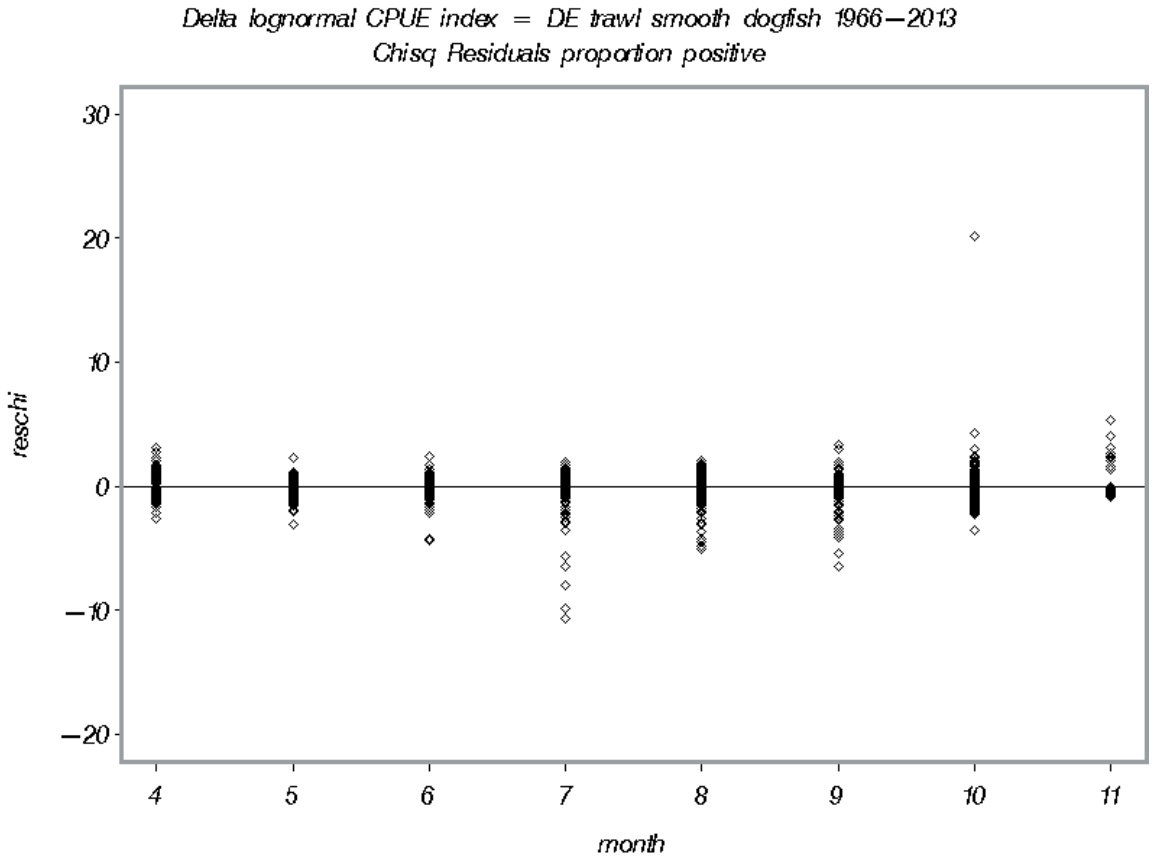
Delta lognormal CPUE index = DE trawl smooth dogfish 1966–2013
Chisq Residuals proportion positive
reschi
30
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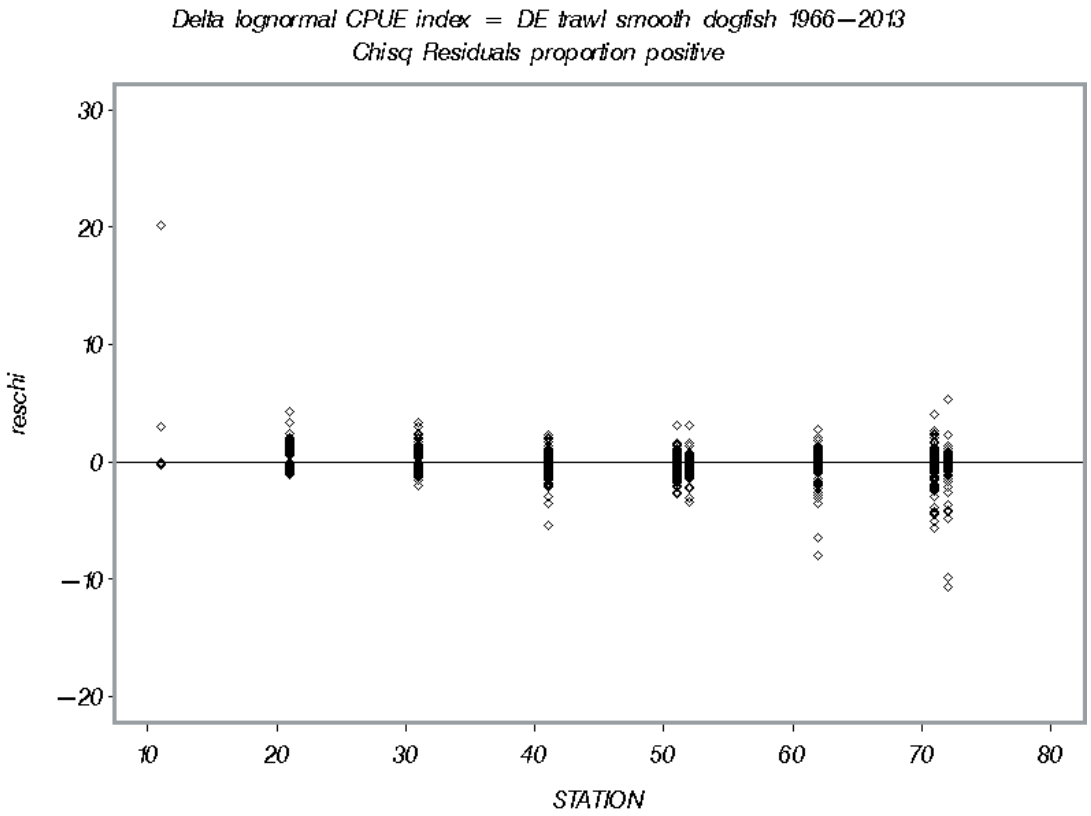
Figure 3a continued. Delaware Bay trawl survey smooth dogfish model diagnostic plots for the binomial component.



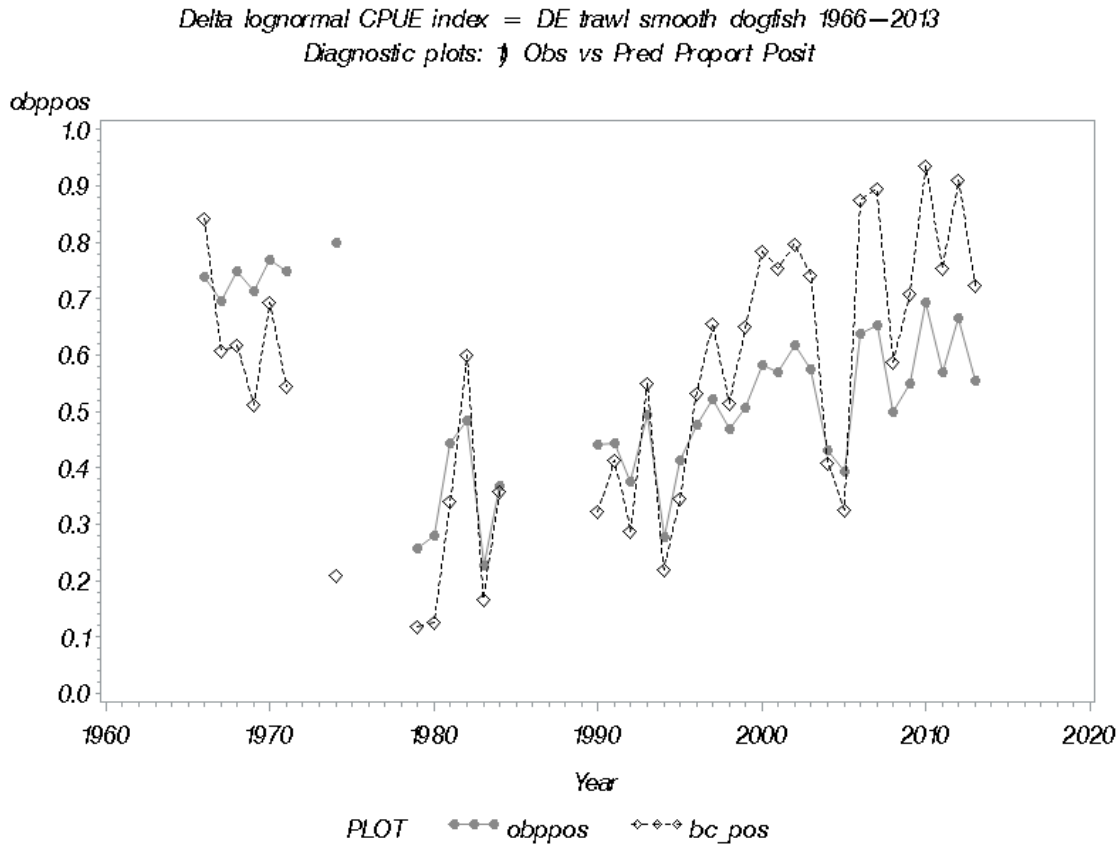
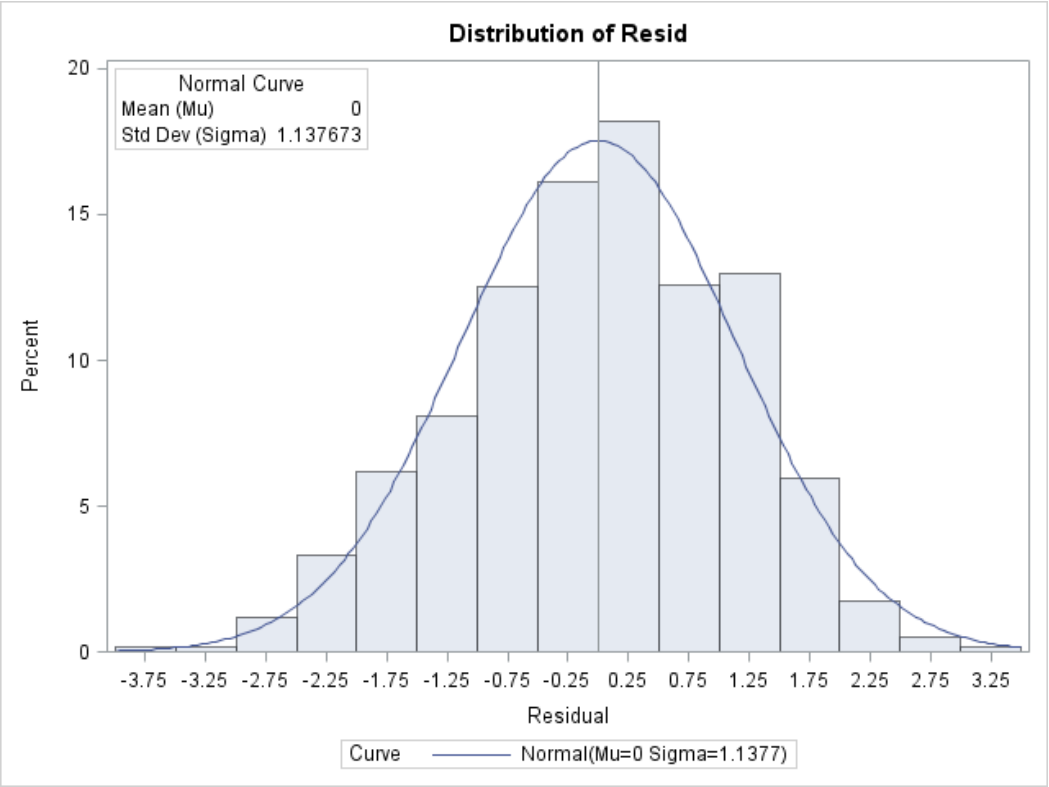


Figure 3b. Delaware Bay trawl survey smooth dogfish model diagnostic plots for lognormal component.



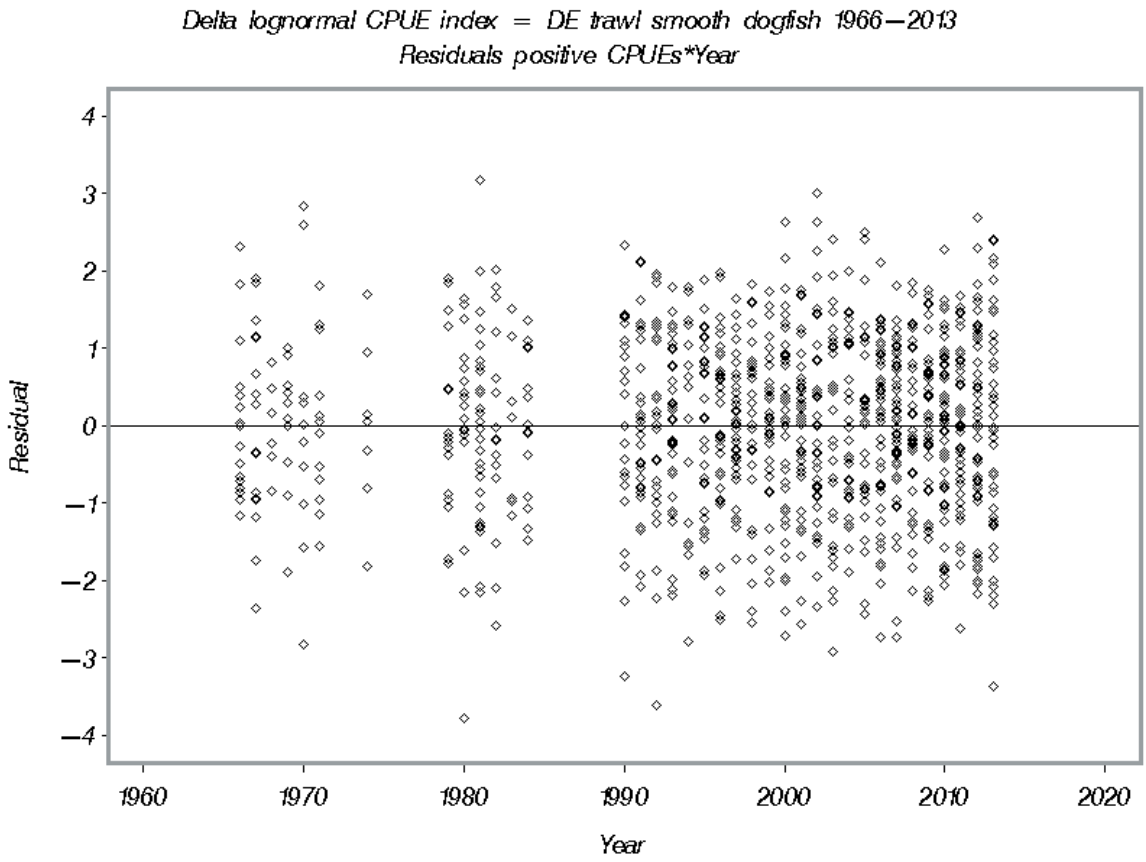
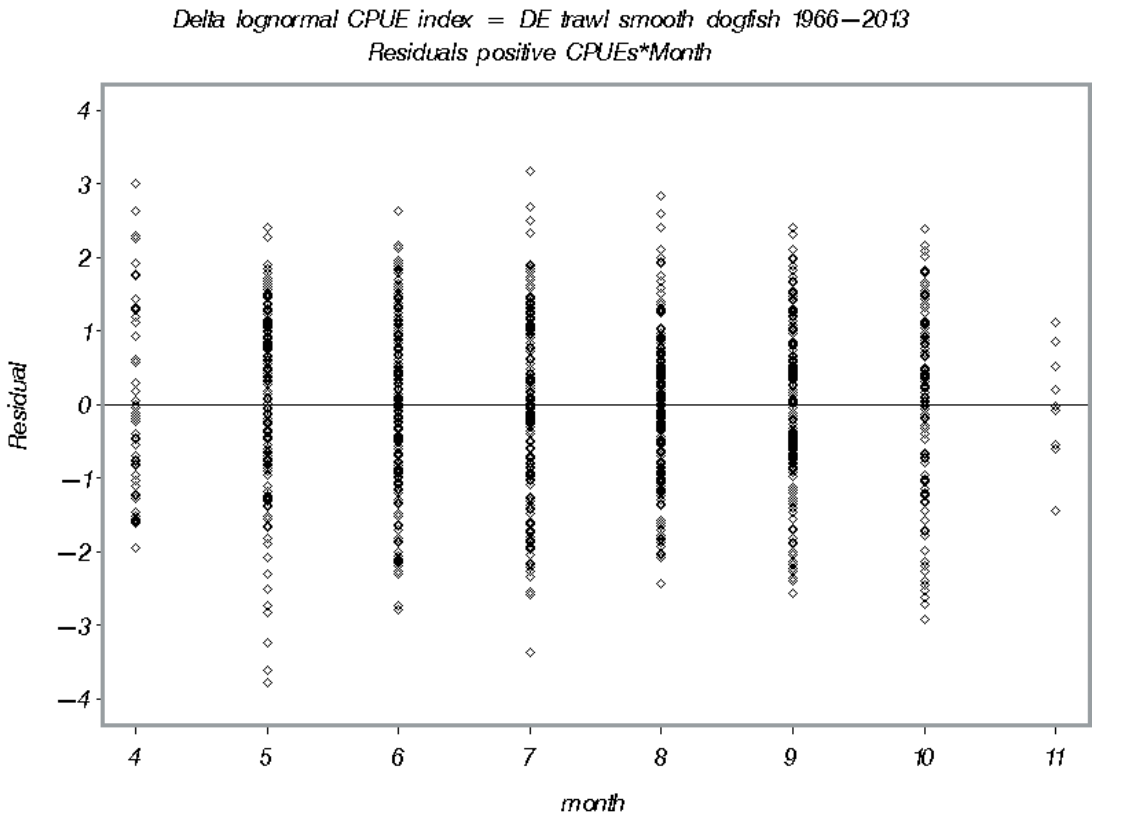


Figure 3b continued. Delaware Bay trawl survey smooth dogfish model diagnostic plots for lognormal component.



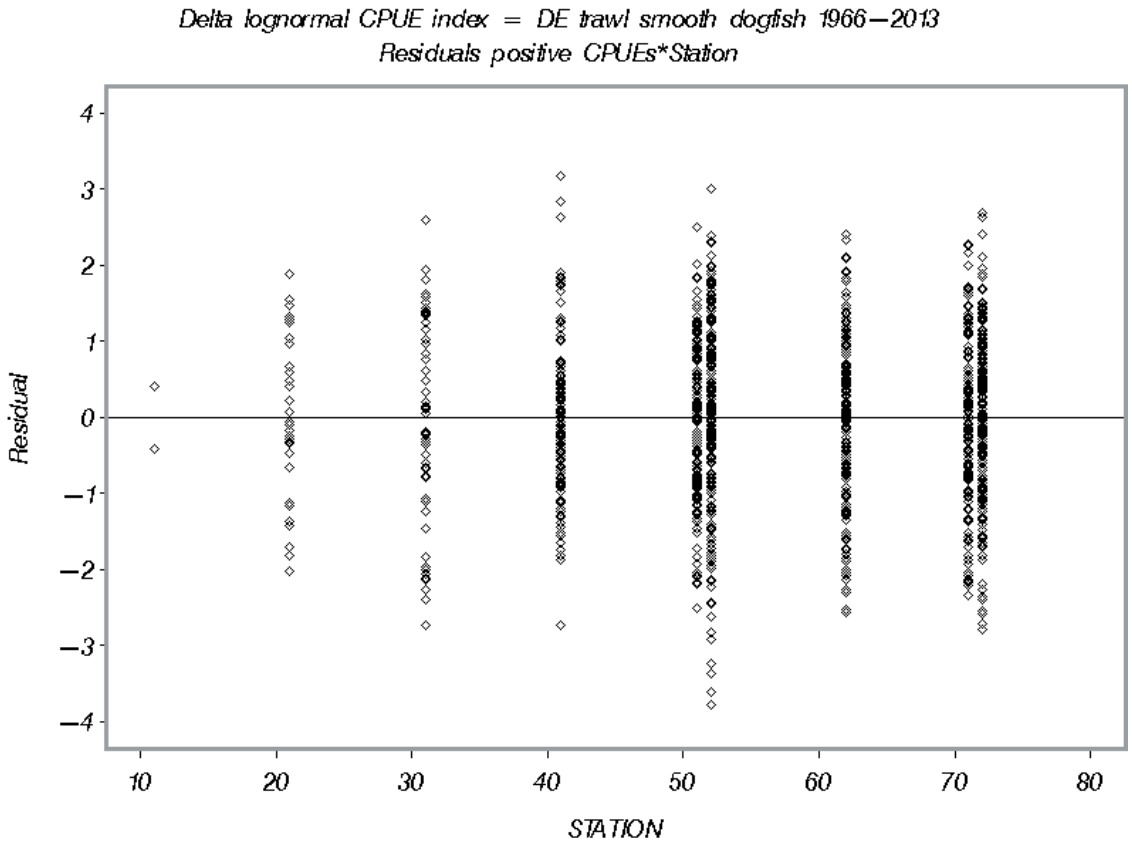


Figure 3b continued. Delaware Bay trawl survey smooth dogfish model diagnostic plots for lognormal component.

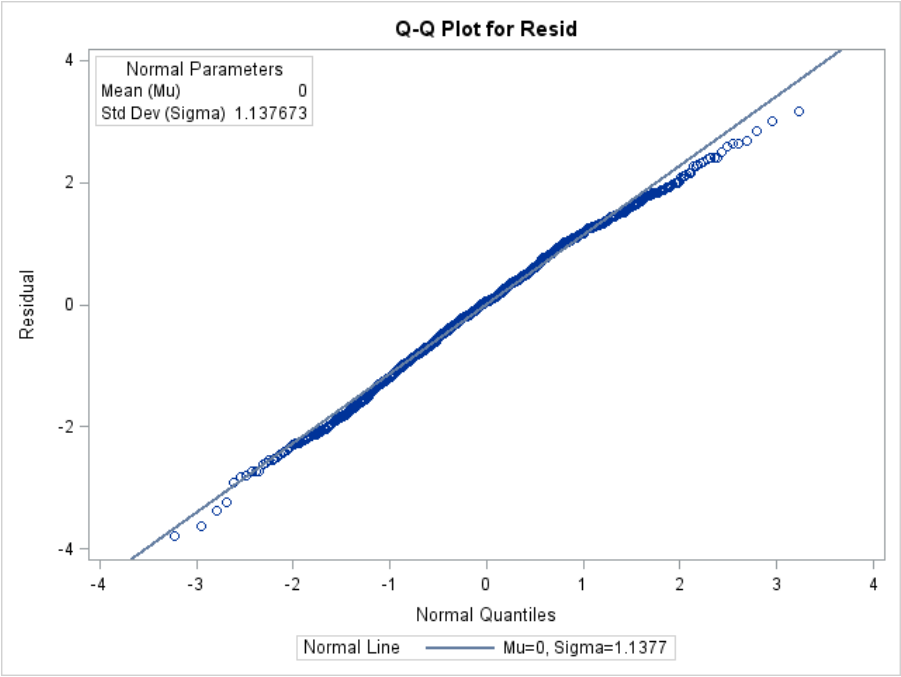
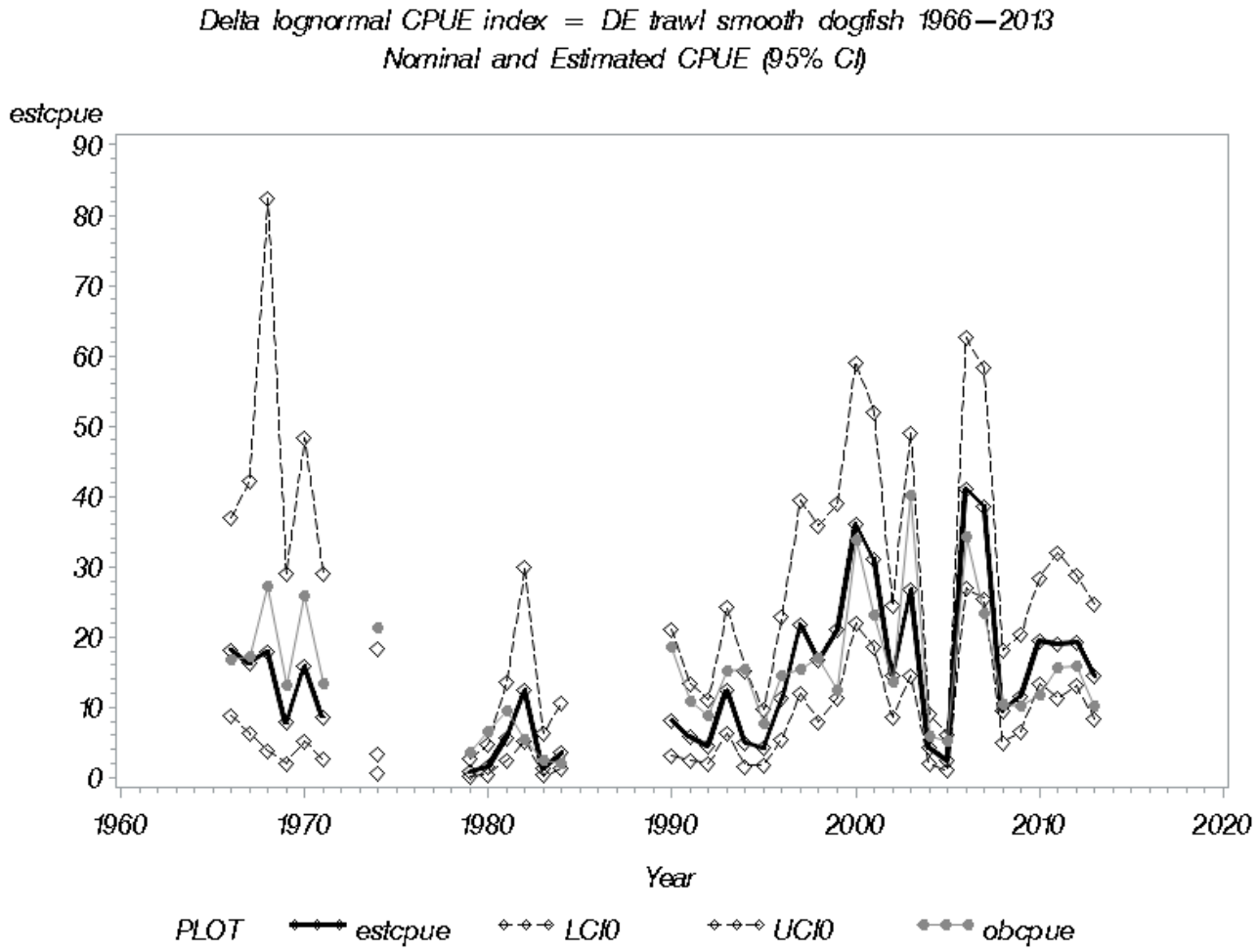


Figure 4. DE trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).



ADDENDUM TO SEDAR39-DW-15

Based on the length of the catch time series that will be used in the assessment model the Delaware Bay 30-foot trawl time series needed to be run through the standardization process (delta-lognormal model) two additional times using the factors from the original model with a start date of 1972 (break in DE time series so will begin in 1974) and 1981; and with an end date for both time series of 2012. The resulting index values and trends are reported below.

Table A1. 1974-2012 DE trawl survey smooth dogfish analysis number of sets (n sets), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as catch per nautical mile towed (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n tows	catch	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
1974	17	321	10	8	0.8000	21.3904	3.0491	0.6143	15.1333	0.9485
1975	.	.	.	.	.	.	.	.	.	.
1976	.	.	.	.	.	.	.	.	.	.
1977	.	.	.	.	.	.	.	.	.	.
1978	.	.	.	.	.	.	.	.	.	.
1979	62	230	62	16	0.2581	3.7108	0.8058	0.2765	2.3485	0.5755
1980	63	423	61	17	0.2787	6.4542	1.4416	0.5096	4.0779	0.5571
1981	67	645	63	28	0.4444	9.5926	5.6909	2.5400	12.7509	0.4203
1982	38	150	33	16	0.4848	5.4153	13.2632	5.8034	30.3119	0.4316
1983	35	91	31	7	0.2258	2.4860	1.3854	0.3374	5.6895	0.8043
1984	42	71	38	14	0.3684	2.0675	3.7795	1.3726	10.4068	0.5407
1985	.	.	.	.	.	.	.	.	.	.
1986	.	.	.	.	.	.	.	.	.	.
1987	.	.	.	.	.	.	.	.	.	.
1988	.	.	.	.	.	.	.	.	.	.
1989	.	.	.	.	.	.	.	.	.	.
1990	50	856	50	22	0.4400	18.5424	7.8410	3.1990	19.2188	0.4718
1991	63	716	63	28	0.4444	10.8893	5.4302	2.4677	11.9490	0.4102
1992	72	688	72	27	0.3750	8.8297	4.4640	1.9616	10.1585	0.4291
1993	71	1181	71	35	0.4930	15.1197	12.0175	6.3859	22.6156	0.3242
1994	54	887	54	15	0.2778	15.3690	4.6011	1.6050	13.1899	0.5653
1995	70	611	70	29	0.4143	7.6038	4.0075	1.8389	8.7333	0.4047
1996	67	1087	67	32	0.4776	14.4333	10.7856	5.4705	21.2648	0.3494
1997	71	1177	71	37	0.5211	15.3430	21.5530	12.2522	37.9141	0.2881
1998	62	1234	62	29	0.4677	16.9315	16.7899	8.2648	34.1084	0.3658
1999	69	903	69	35	0.5072	12.4631	20.9375	11.7263	37.3846	0.2961
2000	72	2518	72	42	0.5833	33.7167	35.1260	21.8938	56.3556	0.2397
2001	72	1716	72	41	0.5694	23.1679	30.2588	18.4892	49.5205	0.2501
2002	60	868	60	37	0.6167	13.6410	13.8680	8.3646	22.9923	0.2569
2003	54	2054	54	31	0.5741	40.2734	26.8402	15.1435	47.5716	0.2921
2004	72	422	72	31	0.4306	5.9074	4.1469	1.9954	8.6182	0.3783
2005	71	376	71	28	0.3944	5.2715	2.5274	1.1340	5.6326	0.4173
2006	72	2539	72	46	0.6389	34.2482	40.5412	26.9805	60.9178	0.2057
2007	72	1745	72	47	0.6528	23.3678	38.7541	25.9792	57.8108	0.2020
2008	72	743	72	36	0.5000	10.5156	9.3775	5.1085	17.2140	0.3108
2009	71	738	71	39	0.5493	10.2911	11.4919	6.7558	19.5482	0.2704
2010	72	866	72	50	0.6944	11.8497	19.6432	13.6278	28.3140	0.1844
2011	72	975	72	41	0.5694	15.6967	18.9991	11.5972	31.1254	0.2506
2012	72	1162	72	48	0.6667	15.8505	19.0543	12.9870	27.9563	0.1934

Table A2. 1981-2012 DE trawl survey smooth dogfish analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as catch per nautical mile towed (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

year	n tows	catch	n obs	obs pos	obs ppos	obs cpue	est cpue	LCL	UCL	CV
1981	67	645	63	28	0.4444	9.5926	4.8637	2.0945	11.2941	0.4406
1982	38	150	33	16	0.4848	5.4153	12.0357	5.0561	28.6503	0.4549
1983	35	91	31	7	0.2258	2.4860	1.0330	0.2393	4.4591	0.8408
1984	42	71	38	14	0.3684	2.0675	3.1750	1.0983	9.1780	0.5704
1985	.	.	.	.	.	.	.	.	.	.
1986	.	.	.	.	.	.	.	.	.	.
1987	.	.	.	.	.	.	.	.	.	.
1988	.	.	.	.	.	.	.	.	.	.
1989	.	.	.	.	.	.	.	.	.	.
1990	50	856	50	22	0.4400	18.5424	6.7272	2.6530	17.0579	0.4916
1991	63	716	63	28	0.4444	10.8893	4.6204	2.0155	10.5918	0.4333
1992	72	688	72	27	0.3750	8.8297	3.7503	1.5955	8.8156	0.4476
1993	71	1181	71	35	0.4930	15.1197	10.6794	5.5022	20.7282	0.3409
1994	54	887	54	15	0.2778	15.3690	3.9604	1.3487	11.6296	0.5801
1995	70	611	70	29	0.4143	7.6038	3.4058	1.5115	7.6743	0.4235
1996	67	1087	67	32	0.4776	14.4333	9.4671	4.6356	19.3345	0.3687
1997	71	1177	71	37	0.5211	15.3430	19.6196	10.8519	35.4710	0.3027
1998	62	1234	62	29	0.4677	16.9315	14.5893	6.9098	30.8040	0.3871
1999	69	903	69	35	0.5072	12.4631	18.9391	10.3170	34.7667	0.3109
2000	72	2518	72	42	0.5833	33.7167	32.7161	20.0136	53.4810	0.2495
2001	72	1716	72	41	0.5694	23.1679	28.0205	16.7691	46.8212	0.2610
2002	60	868	60	37	0.6167	13.6410	12.9067	7.6113	21.8864	0.2687
2003	54	2054	54	31	0.5741	40.2734	25.1719	13.8736	45.6710	0.3046
2004	72	422	72	31	0.4306	5.9074	3.5999	1.6755	7.7348	0.3968
2005	71	376	71	28	0.3944	5.2715	2.1294	0.9235	4.9098	0.4366
2006	72	2539	72	46	0.6389	34.2482	38.5300	25.3694	58.5178	0.2112
2007	72	1745	72	47	0.6528	23.3678	37.0009	24.5831	55.6914	0.2066
2008	72	743	72	36	0.5000	10.5156	8.4142	4.4496	15.9115	0.3268
2009	71	738	71	39	0.5493	10.2911	10.5048	6.0214	18.3264	0.2837
2010	72	866	72	50	0.6944	11.8497	18.9064	13.0539	27.3828	0.1868
2011	72	975	72	41	0.5694	15.6967	17.6523	10.5538	29.5254	0.2615
2012	72	1162	72	48	0.6667	15.8505	18.2241	12.3297	26.9365	0.1972

Figure A1. 1974-2012 DE trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).

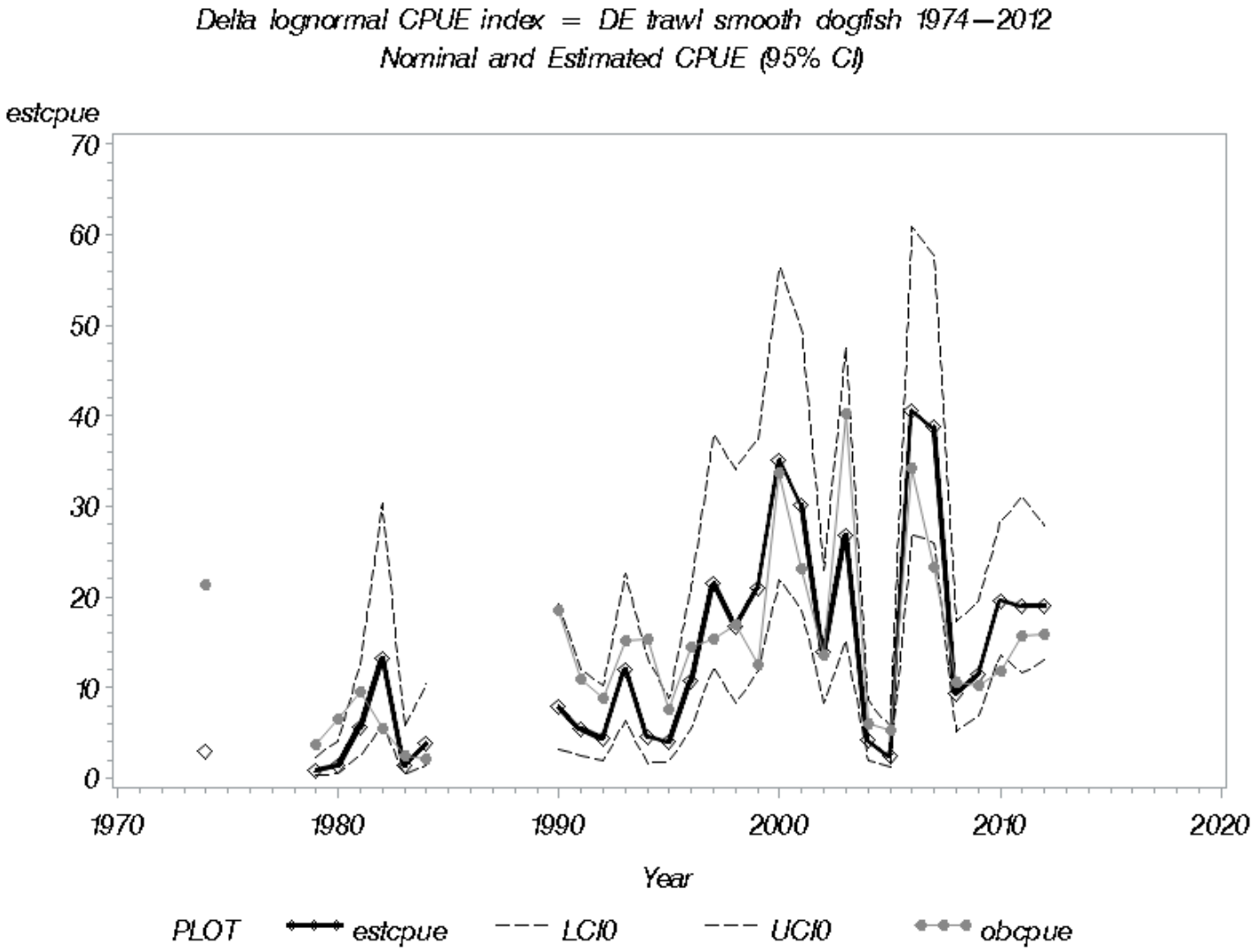


Figure A2. 1981-2012 DE trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).